Inorganic carbon behaviour in the North Atlantic Ocean

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SUMMARY

The North Atlantic ocean exerts a considerable influence on the global climate system. The area is a known sink for carbon dioxide as well as a place where deep water formation takes place due to net heat loss to the atmosphere. The wind driven gyre circulation transports surface waters to the north, the regions where deep water formation due to cooling takes place. Subsequently the deep waters flow southward into the basins of all oceans, thus compensating the gross northward transport. An accurate understanding of the carbon uptake by surface waters as well as its transport by deep ocean circulation are essential in order to quantify the role of the northern North Atlantic in the global carbon budget.

Spatial and temporal variations in the speciation of the inorganic carbon system were investigated during the Joint Global Ocean Flux Studies (JGOFS) in 1989 and 1990. A comparison has been made between two methods for determining total carbon dioxide concentration (TCO_2) in seawater. The Coulometric method determines only TCO_2 whereas the acid titration method also results in the property alkalinity. The latter has been investigated in detail using a Gran plot or curve-fitting routine, combined with different dissociation constants. No statistical significant difference could be found between the two used calculation methods. Only a slight negligible offset between Coulometric and calculated TCO_2 concentrations remained, using the accurate dissociation constants of Goyet and Poisson (1989), making the invocation of interfering (organic) protolytes during the titration superfluous.

The seasonal changes in the upper 20 metres of the ocean were investigated by combining the various databases of the participating countries in the JGOFS project. Primary production resulted in strong uptake of CO_2 from the seawater and appeared to be regulated by nutrient availability. Phytoplankton blooms were not only patchy in distribution but could disappear in a few days after their initiation. Flux calculations showed parts of the ocean to be a permanent sink or source for CO_2, other parts to be both, dependent on the season. The use of ^{14}C measurements and initial pCO_2 concentrations showed the lack of anthropogenic CO_2 penetration into the deep waters.

High resolution measurements of TCO_2 profiles, both vertically and laterally, were obtained during the Dutch World Ocean Circulation Experiment (WOCE) cruise and allowed using total carbon dioxide as a semi-conservative tracer. For the first time watermasses could be labelled with a characteristic TCO_2 concentration. Preformed concentrations of nutrients and TCO_2 were not only used to delineate water mass mixing in the Iceland Basin

but also to explain the biochemical origin of the Intermediate Water mass present.

The combination of total carbon dioxide measurements with estimates of water mass transport in the Iceland Basin was used to quantify carbon transport in this region. Additionally the role of the dissolved organic carbon pool was investigated and was found to be negligible in the view of the large inorganic carbon transports observed. The Iceland Basin appeared to have a net flux of 2.0 $GtC \cdot yr^{-1}$ southward, larger than regognized before. However, uncertainties in geostrophic calculations prevent the determination of an unambigous answer and care should be taken in their interpretation. The compelling dataset indicates the need for further investigation on a seasonal basis in this hydrographically complicated area.